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(71) Applicant : **XEROX CORPORATION**
Xerox Square
Rochester New York 14644 (US)

(72) Inventor : **McNamara, James E.**
6357 Harvest Drive
Sodus, New York 14551 (US)

(74) Representative : **Goode, Ian Roy et al**
Rank Xerox Patent Department,
Albion House,
55-59 New Oxford Street
London WC1A 1BS (GB)

(54) Metal coated photoreceptor substrate.

(57) A process is disclosed for the preparation of a photosensitive imaging member comprising : (a) providing a photoreceptor substrate wherein the substrate surface is marred by at least one surface blemish ; (b) removing at least a portion of the surface blemish when the blemish is a surface height defect, and optionally removing at least a portion of the surface blemish when the blemish is a non-surface height defect ; and (c) depositing a layer of metal on the substrate, wherein the metal layer has a surface appearance which conceals at least a portion of the underlying substrate surface blemish remaining after step (b).

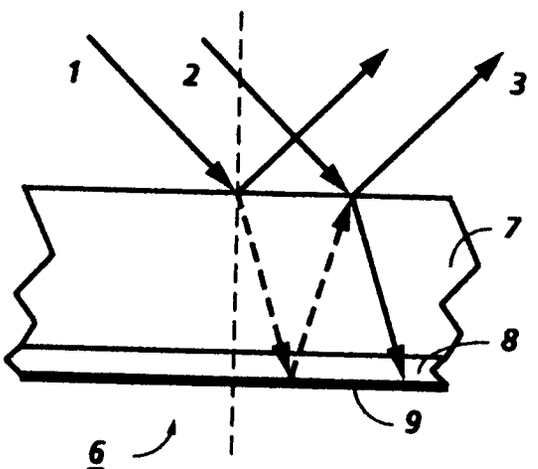

FIG. 1
PRIOR ART

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This invention relates generally to photoreceptors and the preparation thereof, and more particularly to photoreceptor substrates and their preparation.

In the process of fabricating photoreceptor substrates, there may result substrates having surface blemishes, substandard dimensions, or both. Substrates having surface blemishes and substandard dimensions are typically deemed unsuitable for use in photoreceptor applications and are discarded since these substrates fail to meet testing requirements, performance requirements, and/or customer perceptions. It would be economical if these substandard substrates could be reclaimed for use as photoreceptor substrates.

In addition, there is a need for a photoreceptor substrate that suppresses optical interference occurring within a photosensitive member. When not suppressed, the optical interference results in a defect that resembles the grain in a sheet of plywood in output prints derived from the exposed photosensitive member when the exposure is a uniform, intermediate-density gray. There are numerous applications in the electrophotographic art wherein a coherent beam of radiation, typically from a helium-neon or diode laser is modulated by an input image data signal and is directed (scanned) across the surface of a photosensitive medium which, in the case of "layered photoreceptors", has at least a partially transparent photosensitive layer overlying a conductive ground plane (also referred to as a substrate). A problem inherent in using these layered photoreceptors, depending upon the physical characteristics, is the creation of two dominant reflections of the incident coherent light on the surface of the photoreceptor, e.g., a first reflection from the top surface and a second reflection from the top surface of the relatively opaque conductive ground plane. This condition is shown in Fig. 1 where coherent beams 1 and 2 are incident on a layered photoreceptor 6 comprising a charge transport layer 7, charge generator layer 8, and a ground plane 9. The two dominant reflections are from the top surface of layer 7, and from the top surface of ground plane 9. Depending on the optical path difference as determined by the thickness and index of refraction of layer 7, beams 1 and 2 can interfere constructively or destructively when they combine to form beam 3. When the additional optical path traveled by beam 1 (dashed rays) is an integer multiple of the wavelength of the light, constructive interference occurs, more light is reflected from the top of charge transport layer 7 and, hence, less light is absorbed by charge generator layer 8. Conversely, a path difference producing destructive interference means less light is lost out of the layer and more absorption occurs within the charge generator layer 8. The difference in absorption in the charge generator layer 8, typically due to layer thickness variations within the charge transport layer 7, is equivalent to a spatial variation in exposure on the surface. This spatial exposure variation present in the image formed on the photoreceptor becomes manifest in the output copy derived from the exposed photoreceptor. Figure 2 shows the areas of spatial exposure variation (at 25x) within a photoreceptor of the type shown in Figure 1 when illuminated by a He-Ne laser with an output wavelength of 633 nm. The pattern of light and dark interference fringes look like the grains on a sheet of plywood. Hence the term "plywood effect" is generically applied to this problem.

US-A-4,067,782 discloses a process for nickel plating a cylindrically shaped hollow core mandrel suitable for chromium plating for use in an electroforming process for the production of endless seamless nickel xerographic belts.

US-A-5,069,758 discloses a process for suppressing the plywood effect in photoreceptors by forming the ground plane surface with a rough surface morphology using an electroforming process which leaves the surface with a matte-like finish.

US-A-5,096,792 discloses a layered photosensitive imaging member modified to reduce the plywood effect. The modification described is to form the ground plane surface with a rough surface morphology by various selective metal deposition methods.

It is an object of the present invention in embodiments to reclaim substandard photoreceptor substrates.

It is a further object to provide a process for metal coating photoreceptor or imaging member substrates.

It is still another object in embodiments to provide substrates with a metal layer having a surface morphology effective for reducing or suppressing the plywood effect.

It is an additional object in embodiments to provide a layer of metal sufficient to increase the dimensions of the substrate to the desired standard.

It is also an object in embodiments to metal coat photoreceptor substrates using electroplating or electroless metal deposition techniques.

The present invention provides a process for the preparation of a photosensitive imaging member comprising: (a) providing a photoreceptor substrate wherein the substrate surface is marred by at least one surface blemish; (b) removing at least a portion of the surface blemish when the blemish is a surface height defect, and optionally removing at least a portion of the surface blemish when the blemish is a non-surface height defect; and (c) depositing a layer of metal on the substrate, wherein the metal layer has a surface appearance which conceals at least a portion of the underlying substrate surface blemish remaining after step (b).

The invention further provides a process for the preparation of a photosensitive imaging member according to claim 9 or 10 of the appended claims.

Preferably, the metal layer has a surface roughness sufficient to substantially suppress the formation of a pattern of light and dark interference fringes upon exposure of the photosensitive imaging member Preferably, the metal layer has a surface roughness defined by one or more of the following parameters: R_a having a value ranging from about 0.05 to about 0.7 μm; R_q having a value ranging from about 1 to about 6 μm; R_t having a value ranging from about 0.5 to about 6 μm; R_{pm} having a value ranging from about 0.2 to about 2 μm; W_t having a value ranging from about 0.1 to about 1 μm; P_t having a value ranging from about 0.8 to about 6 μm. Preferably, the metal is copper or nickel. Preferably, the metal layer is deposited by electroplating.

The phrase "surface blemish" or surface blemishes" refers to surface defects including scrapes, nicks, scratches, coating defects, imperfections in the material of the substrate, surface spots, discolorations caused by for example water spots, mixtures thereof, and the like. A blemish may be generally a surface height defect such as scrapes, nicks, scratches, bumps, and the like, or a non-surface height defect such as surface spots, discolorations, and the like.

Other aspects of the present invention will become apparent as the following description proceeds and upon reference to the Figures, in which:

Fig. 1 shows coherent light incident upon a prior art layered photosensitive medium leading to reflections internal to the medium.

Fig. 2 shows a spatial exposure variation plywood pattern in the exposed photosensitive medium of Fig. 1 produced when the spatial variation in the absorption within the photosensitive member occurs due to an interference effect.

To prepare the metal coated photoreceptor substrate, there is first provided a formed photoreceptor substrate. The term "formed" refers for example to a fabricated substrate as distinguished from a substrate which is undergoing fabrication whether by electroforming, by extrusion, or by any other conventional fabrication technique. The term "formed" includes substrates having finished surfaces, such as by machining and/or buffing, and unfinished surfaces. The substrate can be formulated entirely of an electrically conductive material, or it can be an insulating material having an electrically conductive surface. The substrate can be opaque or substantially transparent and can comprise numerous suitable materials having the desired mechanical properties. The entire substrate can comprise the same material as that in the electrically conductive surface or the electrically conductive surface can merely be a coating on the substrate. Any suitable electrically conductive material can be employed. Typical electrically conductive materials include metals like copper, brass, nickel, zinc, chromium, stainless steel; and conductive plastics and rubbers, aluminum, semitransparent aluminum, steel, cadmium, titanium, silver, gold, paper rendered conductive by the inclusion of a suitable material therein or through conditioning in a humid atmosphere to ensure the presence of sufficient water content to render the material conductive, indium, tin, metal oxides, including tin oxide and indium tin oxide, and the like. The substrate layer can vary in thickness over substantially wide ranges depending on the desired use of the electrophotoconductive member. Generally, the conductive layer ranges in thickness of from about 50Å to 10cm, although the thickness can be outside of this range. When a flexible electrophotographic imaging member is desired, the substrate thickness typically is from about 100Å to about 0.015 mm. The substrate can be of any other conventional material, including organic and inorganic materials. Typical substrate materials include insulating non-conducting materials such as various resins known for this purpose including polycarbonates, polyamides, polyurethanes, paper, glass, plastic, polyesters such as MYLAR® (available from DuPont) or MELINEX 447® (available from ICI Americas, Inc.), and the like. If desired, a conductive substrate can be coated onto an insulating material. In addition, the substrate can comprise a metallized plastic, such as titanized or aluminized MYLAR®, wherein the metallized surface is in contact with the photosensitive layer or any other layer situated between the substrate and the photosensitive layer. The coated or uncoated substrate can be flexible or rigid, and can have any number of configurations, such as a plate, a cylindrical drum, a scroll, an endless flexible belt, or the like. The outer surface of the substrate preferably comprises a metal oxide such as aluminum oxide, nickel oxide, titanium oxide, and the like.

The substrate may be of any dimension conventionally employed in photoreceptors. For example, in embodiments, hollow cylindrical substrates may have an inside diameter ranging from about 0.7874 inch (20 mm) to about 30 inches (76.2cm), an outside diameter ranging from about 0.7884 inch to about 30.5 inches (77.5cm), a length ranging from about 7 to about 44 inches (17.8 to about 111.8cm), and a wall thickness ranging from about 0.001 to about 4 inches (25.4μm to about 10.16cm).

The substrate is optionally provided with an anodizing treatment to form a protective film, e.g., an oxide film, on the substrate surface so that the substrate can be placed into the subsequent metal deposition bath and the protective film will be inert to the bath long enough to obtain a metal layer on the substrate. It is understood that the materials and numerical parameters expressly recited herein for the anodizing treatment are preferred embodiments and that materials and numerical parameters outside those expressly recited may be employed. The anodizing treatment may be accomplished in embodiments by establishing an anodizing zone which com-

prises a suitable metal cathode selected, for example, from the group consisting of lead, aluminum, stainless steel, and lead alloys such as lead/tin. The anode comprises the substrate. The cathode and the substrate anode are separated by an anodizing bath maintained at a temperature of from about 60° to about 100°F (about 15.5 to 37°C), and preferably about 78° to about 80°F (about 25.6 to 32.2°C). A more preferred temperature in embodiments is 79°F (26.1°C). After the substrate anode has been exposed to the bath for an effective time, preferably from about 1 to about 3 minutes without any voltage applied, then the voltage is applied gradually. The voltage is raised to about 12 to about 25V, and preferably to about 15 to 17V over a period of about 1 to about 2 minutes. More preferably, the voltage is raised to 16V over a period of 1.5 minutes and maintained at 16V for 13.5 minutes. During this period, sufficient agitation may be imparted to the anodizing bath to continuously expose the substance anode to fresh anodizing bath. Preferably, the substrate anode is rotated at 1.5 to 3 rpms in order to obtain sufficient agitation. The anodizing bath is maintained within the zone at a stable equilibrium composition comprising for example in embodiments: 2.7 to 3.7 parts conc. of a suitable acid such as H_3PO_4 to 6.3 to 7.3 parts H_2O. The preferred amount of H_3PO_4 in the anodizing bath is in the amount of: 3.0 parts H_3PO_4 to 7.0 parts H_2O.

Subsequently, the substrate anode is removed from the anodizing bath preferably while the voltage is still being applied to the anodizing bath. The substrate anode may be rinsed with any suitable solvent such as water to remove the anodizing bath solution from the substrate anode. A preferred rinsing step is with water at a rate of at least 1.5 to 2 gallons per minute (5.7 to 7.6 l/min) while the substrate anode is rotated at 7 to 10 rpms for at least 6 complete revolutions. The most preferred rinsing step at this point is after the substrate has been rinsed as just described, the substrate is rinsed again with water at a rate of 5 gallons per minute (19l/m) while rotating the substrate anode at 30 to 40 rpms for 1 to 2 minutes.

A metal deposition zone is then established which comprises a suitable metal anode selected from the metals described herein and preferably selected from the group consisting of nickel and nickel alloy, and a cathode comprising the substrate. It is understood that the materials and numerical parameters expressly recited herein for the metal deposition step are preferred embodiments and that materials and numerical parameters outside those expressly recited may be employed. The substrate cathode and anode are separated by a metal bath maintained at any effective temperature such as from about 120° to about 160°F (48.9 to 71.1°C), and especially from about 132° to about 138°F (55.6 to 58.9°C). The preferred temperature is 135°F (57.2°C). A current, i.e. ramp current, may be applied when the substrate cathode enters the nickel bath of from about 10 to 20 A/ft^2 (107.5 to 215 A/m^2). A voltage of 3 volts may be applied. The preferred rotation of the cathode at this point when the substrate cathode enters the nickel bath is 28 to 32 rpms, while the preferred current density is maintained at 10 to 20 A/ft^2 (107.5 to 215 A/m^2) and the preferred voltage is maintained at 3V. Then the current, i.e., ramp current, may be increased over a period of at least 5 seconds, preferably from about 30 seconds to 3 minutes, to about 75 to 300 A/ft^2 (806.3 to 3225 A/m^2). Preferably, at this time the rotation of the substrate cathode is at 36 to 40 rpms after the preferred ramp current is increased to about 75 to 300 A/ft^2 (806.3 to 3225 A/m^2). The most preferred ramp current increase is where the ramp current is increased to about 100 to about 200 A/ft^2 (1075 to 2150A/m^2) over a period of 5 seconds to about 2 minutes while the substrate is rotated at 36 to 40 rpms.

The metal bath is preferably agitated to continuously expose the substrate cathode to fresh metal bath while maintaining the metal bath within the metal deposition zone at a stable equilibrium composition comprising in embodiments:

total metal, any suitable metal illustrated herein such as nickel sulfate or nickel sulfamate, at an effective concentration such as 9 to 11 oz/gal (67.3 to 82.2 g/l), and preferably 10 oz/gal (74.7 g/l) (the recited concentrations for the total metal refer to the metal alone without any counterions and does not include the metal component of the halide compound disclosed herein as $NiX_2 \bullet 6H_2O$);

halide as $NiX_2 \bullet 6H_2O$ at an effective concentration such as 1.0 to 1.4 oz/gal (7.47 to 10.5 g/l), and preferably 1.2 oz/gal (8.96 g/l);

wherein X is a halogen such as chloride, iodine and bromine; and

a suitable inorganic acid such as H_3BO_3 at an effective concentration such as 4.8 to 5.2 oz/gal (35.9 to 38.9 g/l), and preferably 5 oz/gal (37.4 g/l).

The surface tension of the metal bath may be thereafter continuously maintained at about 33 to 42 dynes per cm, and preferably, 38 dynes per cm. The substrate cathode then may be removed from the metal bath while continuously imparting sufficient agitation to the metal bath to continuously expose the substrate cathode to fresh bath. The pH of the metal bath may be, for example, from about 3.6 to about 4.8, preferably 3.8 to 4.3, and most preferably 4.1. The preferred anode to substrate cathode surface area ratio is 1.5 to 1.

Thereafter, the substrate may be removed from the metal bath and rinsed with a suitable solvent such as water, preferably at a rate of about 5 gallons per minute, to remove the metal bath solution from the substrate cathode.

Preferably, the metal anodes may be nickel, carbonyl nickel anodes, electrolytic sulfur depolarized nickel or even carbon or oxygen depolarized anodes.

Preferably, the substrate cathode is rotated at an effective rate of, for example, about 28 to 30 rpms using any suitable equipment such as a spindle, bladder, or gripping fingers coupled to an motor drive unit which has a gear reduction system capable of rotating the substrate. The substrate cathode is then removed from the nickel bath.

The preferred rinsing procedure after metal deposition comprises contacting the substrate cathode with water at an effective rate of, for example, 1.5 to 2 gallons per minute (5.7 to 7.6 l/min) while the substrate cathode is being rotated at 7 to 10 rpms for at least 6 complete revolutions. The most preferred rinsing step to remove the nickel bath comprises rinsing the substrate with water at a rate of 5 gallons per minute (19 l/m) while rotating the substrate cathode at 30 to 40 rpms for 5 to 10 minutes.

In other embodiments, it is believed that the substrate may be metal coated by any other suitable technique such as vacuum deposition and electroless deposition. Various electroless metal deposition processes are illustrated, for example, US-A-4,666,735 and US-A-3,632,435. Although the electroless deposit of metal may be accomplished in embodiments without the creation of metal nucleating sites on the substrate surface, such nucleating sites are preferred to facilitate the subsequent electroless deposit of the metal. Metal nucleating sites may be created by any suitable process including coating of a colloidal material, in an effective amount, onto the substrate surface to further the sensitization or activation of the same for the electroless metal deposition. The colloidal material applied to the substrate may be selected from colloids conventionally used in the activation of a support for electroless deposition. As described hereafter, the activation of the substrate may be conducted in one or more steps.

When a one step activation procedure is utilized, the surface of the substrate is contacted with an acidic aqueous bath containing an effective amount of a mixture of a noble metal salt and a reducing agent for the noble metal cation. A colloidal material which is catalytic to the metal to be deposited is coated upon the surface of the substrate. Illustrative examples of such baths from which the catalytic colloid may be applied are disclosed in US-A-3,011,920.

In embodiments, a variation of the single step activation procedure may be employed using an acceleration step such as that illustrated in US-A-3,011,920. A substrate sensitizer containing, for example, stannous chloride was combined with palladium chloride to form a colloidal dispersion of a catalytic metal. Stannous chloride in the combined system also may act as a protective colloid for the catalyst, stabilizing the catalyst against agglomeration and premature precipitation. Excess stannous ions relative to palladium ions may stabilize the catalyst. An optional acceleration step may remove the protective colloid from the catalyst metal after the catalyst metal has been deposited on the substrate and prior to deposition of the conductive metal. The acceleration step may use an effective amount of, for example, an alkaline material or preferably a dilute acid, such as hydrochloric acid, wherein the acceleration step is believed to lead to stronger adsorption and bonding of the conductive metal to the substrate.

Alternatively, an effective amount of a colloidal material such as a metallic salt, capable of reducing a noble cation, e.g., a colloidal stannous salt, may initially be applied from a bath containing the same to coat the substrate. While such a metallic salt alone may be not generally catalytic to the metal which is to be applied, it may subsequently be contacted with an additional bath containing an effective amount of a salt of a noble metal, and the substrate accordingly activated as the cation of the noble metal salt is reduced and deposited upon the substrate at the same location previously occupied by the colloidal metallic salt prior to the oxidation of the cation.

The colloidal metallic salt which is applied to the surface of the substrate is lyophobic, and preferably hydrophobic. Stannous salts, such as stannous chloride ($SnCl_2$), are preferred colloidal materials commonly used in the preparation of a substrate for electroless deposition. Such colloids in effective amounts may be applied to a substrate while suspended in a dilute aqueous hydrochloric acid solution. A colloidal metallic salt, such as a stannous chloride, serves to prepare the surface of the substrate to receive a noble metal. Upon contact with the surface of the substrate, a coating or film of a colloidal material is effectively deposited thereupon. When the surface of the substrate is negatively charged, the colloidal film is not merely deposited thereon, but is electrically attached to the surface.

It is understood that nucleating sites may be created by the use of effective amounts of a noble metal, stannous salts, or mixtures thereof, and the like. In embodiments, stannous salts can form nucleating sites without the use of noble metal salts. Noble metal cations include gold, silver, platinum, palladium, iridium, rhenium, mercury, ruthenium, or osmium, and the like. Suitable counterions to the noble metal cations include acetate and halogens such as chloride and bromide, and the like.

Representative metals that may be used to coat the substrate include tin, aluminum, iron, steel, nickel, copper, gold, silver, platinum, palladium, mixtures thereof, and the like.

In embodiments, the metal layer deposited on the substrate may be of any effective thickness, preferably ranging from about 10 microns to about 5 mm, and more preferably from about 10 to about 100 microns.

In embodiments, the substrate surface is marred by at least one surface blemish, and preferably a plur-

ality of surface blemishes. In embodiments, the layer of metal deposited on the substrate has a surface appearance which conceals at least a portion of the underlying substrate surface blemish or blemishes, and preferably conceals all of the underlying blemishes. The term "conceals" indicates that the surface appearance of the portion of the metal layer overlying the blemish is virtually indistinguishable from the surface appearance of the metal layer overlying an unblemished portion of the substrate surface. In certain embodiments, at least a portion, and preferably all of the surface blemishes are removed prior to the deposition of the metal layer. Removal may be accomplished by any suitable technique including machining away the blemishes using, for example, a lathe to rotate the substrate and a cutting tool to remove the blemishes. Removal of the surface blemishes may decrease the substrate dimensions to an extent where the substrate is unacceptable for use as a photoreceptor substrate In such situations, sufficient metal may be deposited on the substrate to increase the dimensions thereof to render the substrate suitable for use as a photoreceptor substrate.

In certain embodiments, there is provided a photoreceptor substrate wherein the substrate surface is marred by at least one blemish, wherein the blemish is a surface height defect. A layer of metal having a thickness as disclosed herein is deposited on the substrate surface to cover at least the blemish, wherein the metal layer has a surface appearance which reflects the underlying substrate surface blemish, thereby resulting in a metal layer marred by at least one surface blemish. Subsequently, at least a portion of the blemish appearing on the surface of the metal layer is removed, and preferably without exposing the underlying substrate surface. Removal may be accomplished by any suitable technique including machining away the blemishes using, for example, a lathe to rotate the substrate and a cutting tool to remove the blemishes.

In embodiments, the deposited metal layer has a surface roughness which is effective for substantially reducing the plywood effect. The metal layer, deposited by the methods disclosed herein, may have in embodiments the requisite plywood suppression surface morphology without a further surface roughening treatment. For example, US-A-5,096,792, discloses metal deposition processes which form the ground plane surface with a rough surface morphology effective for suppressing the plywood effect. In certain embodiments, a separate surface roughening step is employed to obtain the plywood suppression surface morphology using any effective technique including those illustrated in US-A-4,618,552, such as the sand blast method, the brush polishing method and the anodic oxidation method

The roughness of a particular surface may be defined by several parameters, R_a (mean roughness), R_q (root mean square), R_t (maximum roughness depth), R_{pm} (mean levelling depth), W_t (waviness depth), and P_t (profile depth), the definitions of which are well known. R_a is the arithmetic average of all departures of the roughness profile from the mean line within the evaluation length and in embodiments may be any value effective for substantially suppressing plywood, preferably ranging from about 0.05 to about 0.7 μm, more preferably from about 0.1 to about 0.6 μm, and most preferably from about 0.10 to about 0.55 μm. In embodiments, R_a has a value of from about $\lambda/4N$ to about $\lambda/2N$, wherein λ is the wavelength of the light source which is directed (scanned) across the surface of the photoreceptor and is from about 600 nm to about 900 nm, preferably from about 700 nm to about 800 nm, and N is an optical index of the photosensitive coatings and has a value from about 1 to about 3, and preferably from about 1.2 to about 2.0. R_q is the geometric average of all departures of the roughness profile from the mean line within the evaluation length and in embodiments may be any value effective for substantially suppressing plywood, preferably ranging from about 1 to about 6 μm, and more preferably from about 2 to about 3 μm. R_t is the vertical distance between the highest peak and the lowest valley of the roughness profile R within the evaluation length and in embodiments may be any value effective for substantially suppressing plywood, preferably ranging from about 0.5 to about 6 μm, and more preferably from about 0.8 to about 4.5 μm. R_{pm} is the mean of five levelling depths of five successive sample lengths and in embodiments may be any value effective for substantially suppressing plywood, preferably ranging from about 0.2 to about 2 μm, and more preferably from about 0.3 to about 1.5 μm. W_t is the vertical distance between the highest and lowest points of the waviness profile W within the evaluation length and in embodiments may be any value effective for substantially suppressing plywood, preferably ranging from about 0.1 to about 1 μm, and more preferably from about 0.15 to about 0.5 μm. P_t is the distance between two parallel lines enveloping the profile within the evaluation length at their minimum separation and in embodiments may be any value effective for substantially suppressing plywood, preferably ranging from about 0.8 to about 6 μm, and more preferably from about 1 to about 4 μm. Significant plywood suppression may be observed in embodiments of the present invention at the light source wavelengths conventionally used, including a light source having a wavelength at 780 nm.

It is understood that in embodiments, even in plywood suppressing ones, the surface morphology of the substrate may be characterized by one or more, but not necessarily all, of the specified values recited for the various surface roughness parameters disclosed herein.

The surface roughness parameters, R_a, R_q, R_t, R_{pm}, W_t, and P_t, can be determined by a Perthen Surface Profilometer Model #S8P, available from Mahr Feinpruef Corp., by utilizing a 5 μm radius contact probe which rides over the surface and directly, by contact, measures the surface contour. An alternate attachment for the Perthen Surface Profilometer Model #S8P can measure the surface by projecting a laser beam onto the surface and measuring the change in focal length observed as the beam scans across the surface. It is understood that other devices and methods equivalent to those disclosed herein may also be employed to measure the various surface roughness parameters.

After the metal coated substrate is formed, one or more layers are deposited in succession thereon to prepare the photosensitive imaging member. The composition and deposition of these additional layers are known to those skilled in the art. For example, one or more photosensitive layers are typically deposited on the substrate. In embodiments, a charge transport layer such as an arylamine, reference for example US-A-4,265,660, and a charge generating layer comprise the photosensitive layers. This is referred to as a laminate or layered type photosensitive material. Charge transport and charge generating layers may be deposited by any suitable conventional technique including dip coating and vapor deposition and are well known in the art as illustrated for example in US-A-s4,390,611; 4,551,404; 4,588,667; 4,596,754; and 4,797,337. In embodiments, the charge generation layer may be formed by dispersing a charge generating material selected from, for example, azo pigments such as Sudan Red, Dian Blue, Janus Green B, and the like; quinone pigments such as Algol Yellow, Pyrene Quinone, Indanthrene Brilliant Violet RRP, and the like; quinocyanine pigments; perylene pigments; indigo pigments such as indigo, thioindigo, and the like; bisbenzoimidazole pigments such as Indofast Orange toner, and the like; phthalocyanine pigments such as copper phthalocyanine, aluminochlorophthalocyanine, and the like; quinacridone pigments; or azulene compounds in a binder resin such as polyester, polystyrene, polyvinyl butyral, polyvinyl pyrrolidone, methyl cellulose, polyacrylates, cellulose esters, and the like. In embodiments, the charge transport layer may be formed by dissolving a positive hole transporting material selected from compounds having in the main chain or the side chain a polycyclic aromatic ring such as anthracene, pyrene, phenanthrene, coronene, and the like, or a nitrogen-containing hetero ring such as indole, carbazole, oxazole, isoxazole, thiazole, imidazole, pyrazole, oxadiazole, pyrazoline, thiadiazole, triazole, and the like, and hydrazone compounds in a resin having a film-forming property. Such resins may include polycarbonate, polymethacrylates, polyarylate, polystyrene, polyester, polysulfone, styrene-acrylonitrile copolymer, styrene-methyl methacrylate copolymer, and the like.

In embodiments, the photosensitive material may be of a single-layer type comprising the charge generating material, charge transporting material, and the binder resin, wherein these three materials may be as described above. Single layer type photosensitive materials may be deposited by any suitable technique including dip coating and vapor deposition and are illustrated, for example, in US-A-5,004,662 and US-A-4,965, 155.

The invention will now be described in detail with respect to specific preferred embodiments thereof, it being understood that these examples are intended to be illustrative only and the invention is not intended to be limited to the materials, conditions or process parameters recited herein. All percentages and parts are by weight unless otherwise indicated.

EXAMPLE 1

A cylindrical, hollow aluminum substrate, approximately 38 mm in (inside) diameter, about 40 mm in (outside) diameter, about 338 mm in height and walls approximately 1 mm thick, is provided. The substrate surface is marred by a plurality of surface nicks and scratches having a depth less than or equal to 0.076 mm. To remove all of the surface blemishes, the substrate is machined down by about 0.080 mm using a lathe to rotate the substrate at about 20,000 feet per minute (6100 m/min) and employing a diamond cutting tool. The surface of the machined substrate is thus rendered smooth without any visible defects such as nicks, scratches and tool marks. The surface of the substrate has a R_q value ranging from about 1 to about 6 μm. The substrate is blown free of grit or dirt or any foreign material which might cause damage. The substrate is therefore cleaned by washing with acetone to remove any oil and the like. Then those surfaces which are not to be plated are masked. The masking material must be non-reactive with the subsequent plating baths. The ends of the substrate must be plugged or masked so that the inside of the substrate is not plated. The substrate is hooked up to a hoist so that the substrate can be moved between the various baths. The substrate is mounted such that the mounting apparatus and substrate can be rinsed so that all the material on the substrate and mounting, i.e., the previous bath, can be removed by rinsing before entering a subsequent bath. The ends of the substrate are connected to "robbers". The "robbers" steal plating from the ends of the substrate during the plating operation ensuring that the plating on the edges which may be the same as, i.e thickness, the plating in the center of the substrate. The "robber" is such so it can be completely rinsed.

The substrate is given another complete cleaning. Acetone is applied to the surface of the substrate by a squirt bottle to wet the surface of the substrate,

then the surface is wiped with a litho wipe such as a paper cloth, which is damp with acetone. This removes any organic contaminates.

The substrate is then scrubbed to further clean the surface, by for example, chemically cleaning.

The substrate's surface is scrubbed with a nylon pad, i.e., Scotch Brite®, and alpha alumina. The alpha alumina is very fine about 0.3 μm.

Subsequently, the substrate is scrubbed with a soft material, such as paper cloth and then alpha alumina. The substrate is completely scrubbed in both directions.

All traces of the alpha alumina are removed. This is done by flushing the substrate with deionized water while rubbing the surface with clean litho wipes until all the alpha alumina is gone. The substrate is rubbed with the litho wipes until there is no black obtained on the litho wipes. During this process, deionized water is cascaded over the substrate.

The substrate is moved to the anodizing bath. The bath is 3 parts 85% H_3PO_4 to 10 parts deionized water. The temperature of the bath is about 79°F (26.1°C). The bath is about 140 gallons (532l) in a gallon tank. The cathode is of lead and the cathode to anode, i.e. substrate, surface area ratio is 1 to 1. The substrate enters the bath, with no voltage applied to the bath. The substrate is wet from the deionized water rinse. The substrate stands in the anodizing bath for 2 minutes while slowly rotating at about 2.5 rpms, and the voltage is increased slowly and not allowed to exceed 17V. The substrate remains in the anodizing bath for about 15 minutes. The voltage is at 16V. The substrate is removed from the anodizing bath while the voltage is still being applied. A "full rinse" is initiated as soon as the substrate clears the tank to ensure that all the residue of the previous bath is removed from the substrate before the substrate enters the next bath.

A "full rinse" is given to the substrate. The "full rinse" begins with step I where deionized water is directed from a 3/4 inch pipe at about 1.5 to 2 gallons per minute (5.7 to 7.6 l/min) onto the substrate. The substrate is being rotated from about 7 to 10 rpms. This is continued for at least 6 complete revolutions. Then step II is accomplished where the flow of water is increased to about 5 gallons (19 l/min) per minute while rotating the substrate at about 30 to 40 rpms. Then step I is repeated. After this, the substrate is slowed to 7 to 10 rpms while rinsing with deionized water at 1.5 to 2 gallons per minute (5.7 to 7.6 l/min). Then the water is directed at about 1.5 to 2 gallons per minute (5.7 to 7.6 l/min) while the substrate is rotated at about 7 to 10 rpms to specific parts of the substrate, the mounting apparatus and the like, in order to assure that all the crevices are free of any residue from the anodizing bath. The "robber rings" and mounting apparatus should be free of any anodizing bath residue.

The substrate is moved to the nickel bath while it is still wet from the rinse step. The nickel bath is in a 180 gallon (684l) tank with 170 gallons (646l) of nickel bath. The bath is (1) nickel at a concentration of 10 oz/gallon (74.7 g/l), (2) $NiCl_2 \bullet 6H_2O$ at a concentration of 1.2 oz/gallon (8.97 g/l), (3) H_3BO_3 at a concentration of 5 oz/gallon (37.4 g/l). The surface tension is about 38 dynes per cm. The pH is about 4.1. The temperature is about 135°F (57.2°C). The anode is nickel. The anode to cathode, i.e. substrate, surface area ratio is 1.5 to 1.

The substrate enters the nickel bath while the voltage is applied. The substrate is rotating at about 30 rpms. The voltage is about 3V at 15A. As soon as the substrate is completely in the bath, the rotation of the substrate is increased to 35 rpms. The ramp current is increased over a period of 60 seconds from about 15 to about 200 A/ft^2 (161 to 2150 A/m^2). The bath is continuously filtered with a skimmer to remove residue from the top of the bath. The amount of time in the nickel bath depends upon the final desired diameter of the substrate. Here, the substrate stays in the plating bath long enough to increase the substrate diameter by about 0.080 mm of nickel. The final outside diameter of the nickel coated substrate is about 40 mm. After the plating is completed, the substrate is slowly rotated at about 29 rpms during removal from the nickel bath. The "quick rinse" is initiated as soon as the coated substrate starts to clear the nickel bath. The "quick rinse" is the same as step I of the "full rinse" described previously in this example.

The resulting metal coated substrate has a surface roughness characterized by one or more of the following parameters which can be determined by a 5 μm radius stylus used on a Perthometer Model #S8P available from Mahr Feinpruef Corporation: R_a having a value ranging from about 0.05 to about 0.7 μm; R_q having a value ranging from about 1 to about 6 μm; R_t having a value ranging from about 0.5 to about 6 μm; R_{pm} having a value ranging from about 0.2 to about 2 μm; W_t having a value ranging from about 0.1 to about 1 μm; and P_t having a value ranging from about 0.8 to about 6 μm.

Claims

1. A process for the preparation of a photosensitive imaging member comprising:

   (a) providing a photoreceptor substrate wherein the substrate surface is marred by at least one surface blemish;

   (b) removing at least a portion of the surface blemish when the blemish is a surface height defect, and optionally removing at least a portion of the surface blemish when the blemish is a non-surface height defect; and

(c) depositing a layer of metal on the substrate, wherein the metal layer has a surface appearance which conceals at least a portion of the underlying substrate surface blemish remaining after step (b).

2. The process of claim 1, wherein the substrate is comprised of (1) a conductive material, or (2) aluminum, nickel, or a polymeric material incorporating conductive metal particles therein.

3. The process of claim 1 or 2, wherein the substrate is (1) a cylinder, or (2) a belt.

4. The process of claim 1, 2 or 3, wherein the metal layer has a thickness ranging from about 10 to about 100μm.

5. The process of any of the preceding claims, wherein there is removed at least a portion of the surface blemish when the blemish is a non-surface height defect and preferably wherein the removal of at least a portion of the surface blemish is accomplished by machining the substrate surface.

6. The process of claim 5, wherein sufficient material is removed from the substrate surface during removal of the surface blemish to decrease the substrate dimensions to an extent where the substrate is unacceptable for use as a photoreceptor substrate, and wherein in step (c) sufficient metal is deposited on the substrate to increase the dimensions thereof to render the substrate suitable for use as a photoreceptor substrate.

7. The process of any of the preceding claims, wherein there is removed the entire surface blemish.

8. The process of any of the preceding claims, wherein the surface blemish or portion thereof, remaining after step (b), is concealed in its entirety by the metal layer.

9. A process for the preparation of a photosensitive imaging member comprising:
(a) providing a photoreceptor substrate wherein the substrate surface is marred by at least one surface blemish;
(b) removing the surface blemish; and
(c) depositing a layer of metal on the substrate.

10. A process for the preparation of a photosensitive imaging member comprising:
(a) providing a photoreceptor substrate wherein the substrate surface is marred by at least one surface blemish wherein the blemish is a surface height defect;
(b) depositing a layer of metal on the substrate surface to cover at least the blemish, wherein the metal layer has a surface appearance which reflects the underlying substrate surface blemish, thereby resulting in a metal layer marred by at least one surface blemish; and
(c) removing at least a portion of the blemish appearing on the surface of the metal layer.

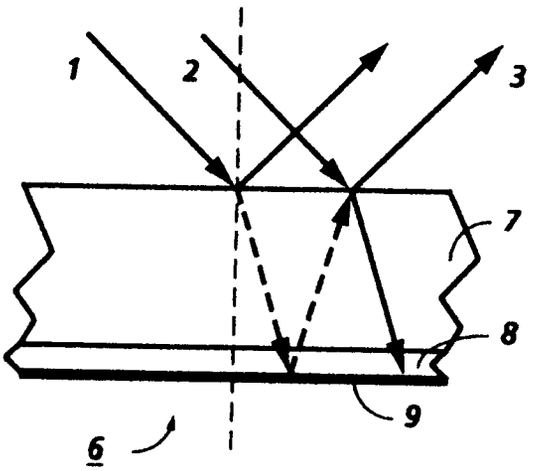

FIG. 1
PRIOR ART

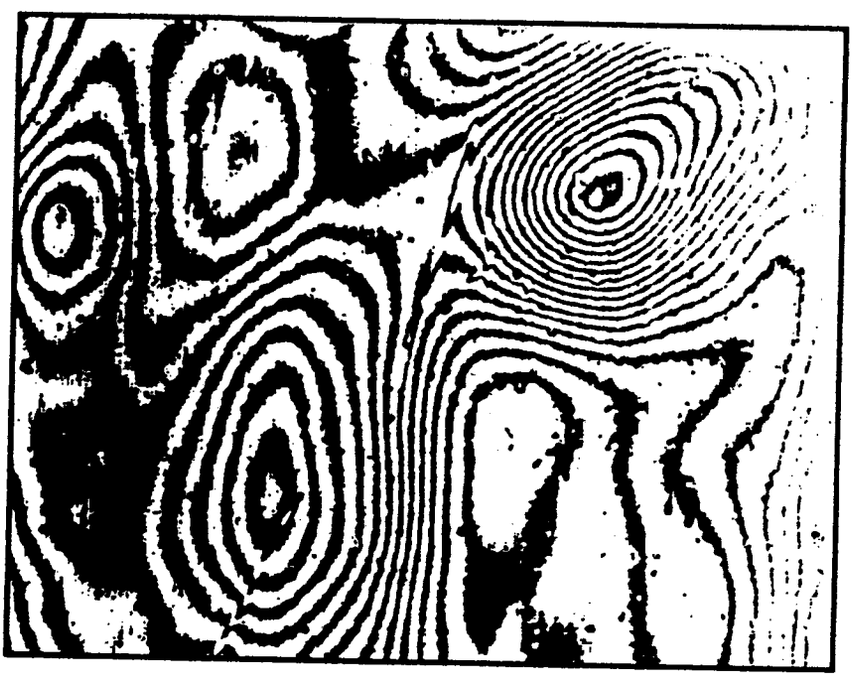

FIG. 2
PRIOR ART

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 94 30 0027

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.5)
D,A	GB-A-2 156 089 (CANON KABUSHIKI KAISHA) * page 4, line 80 - line 104; claim 1; figure 3 *	1-10	G03G5/10
A	EP-A-0 202 746 (CANON KABUSHIKI KAISHA) * page 1, line 17 - page 3, line 5 *	1-10	
A	DE-C-33 11 913 (RICOH CO., LTD.) * page 3, line 40 - line 66; claims 1,2 *	1-10	
A	PATENT ABSTRACTS OF JAPAN vol. 11, no. 22 (P-538)(2469) 21 January 1987 & JP-A-61 194 448 (SHINDENGEN ELECTRIC MFG. CO., LTD.) 28 August 1986 * abstract *	1	
			TECHNICAL FIELDS SEARCHED (Int.Cl.5)
			G03G

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	27 April 1994	Hindia, E

CATEGORY OF CITED DOCUMENTS

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